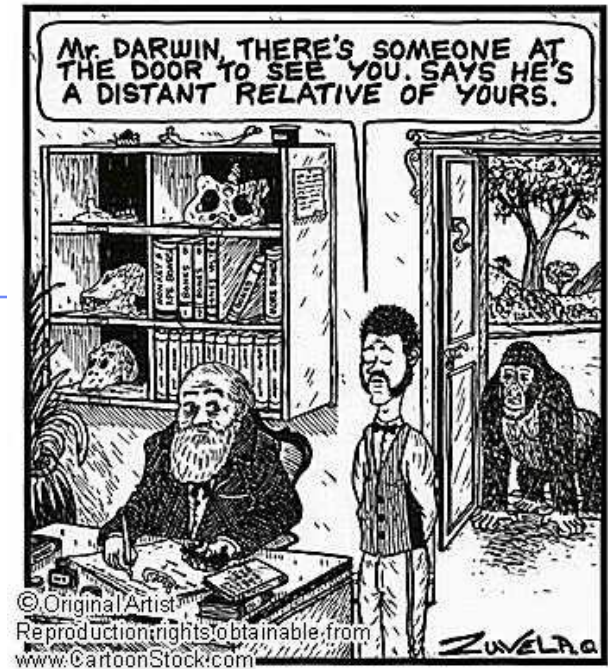


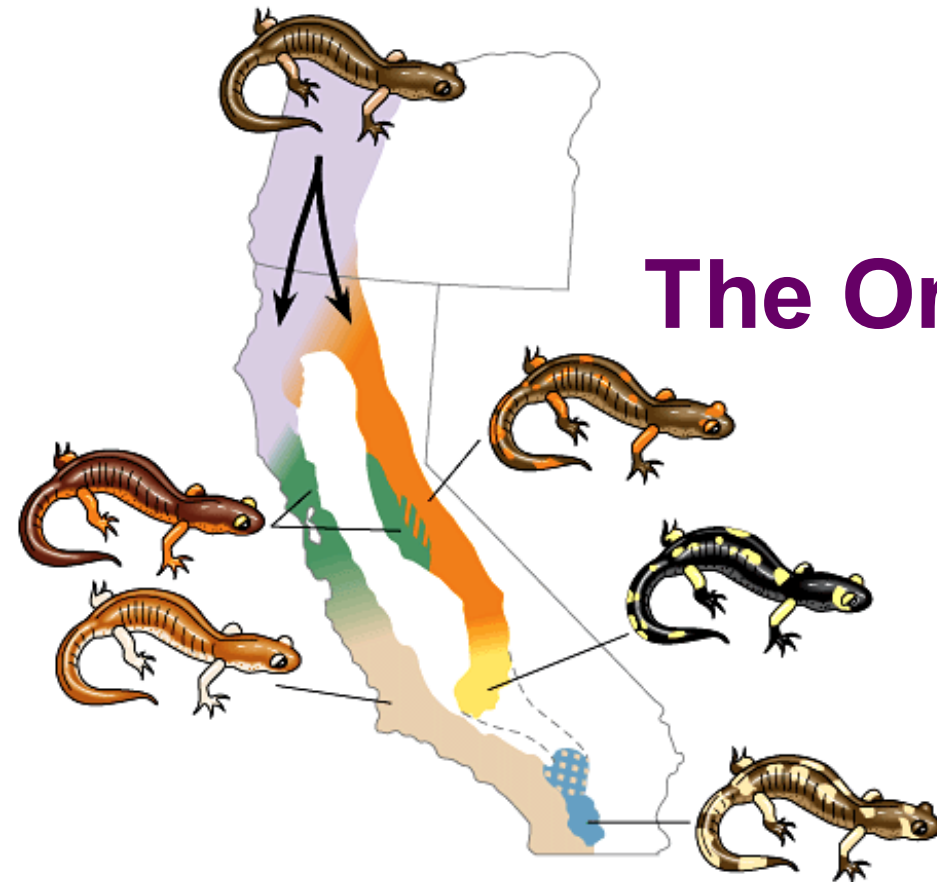
Chapter 24.



The Origin of Species

“Both in space and time, we seem to be brought somewhat near to that great fact—that mystery of mysteries—the first appearance of new beings on this Earth.”

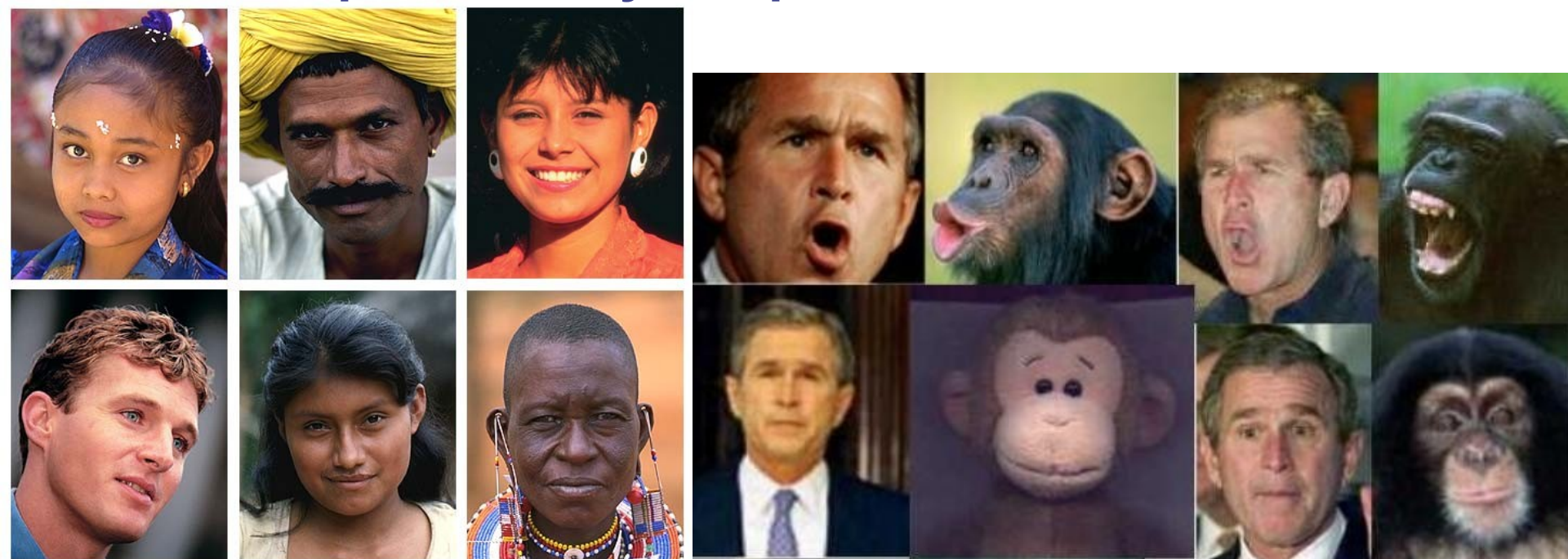
— Darwin



What is a species?

- **Biological species concept**

- ◆ defined by Ernst Mayr
- ◆ population whose members can interbreed & produce viable, fertile offspring
- ◆ reproductively compatible



Biological species concept



Eastern Meadowlark



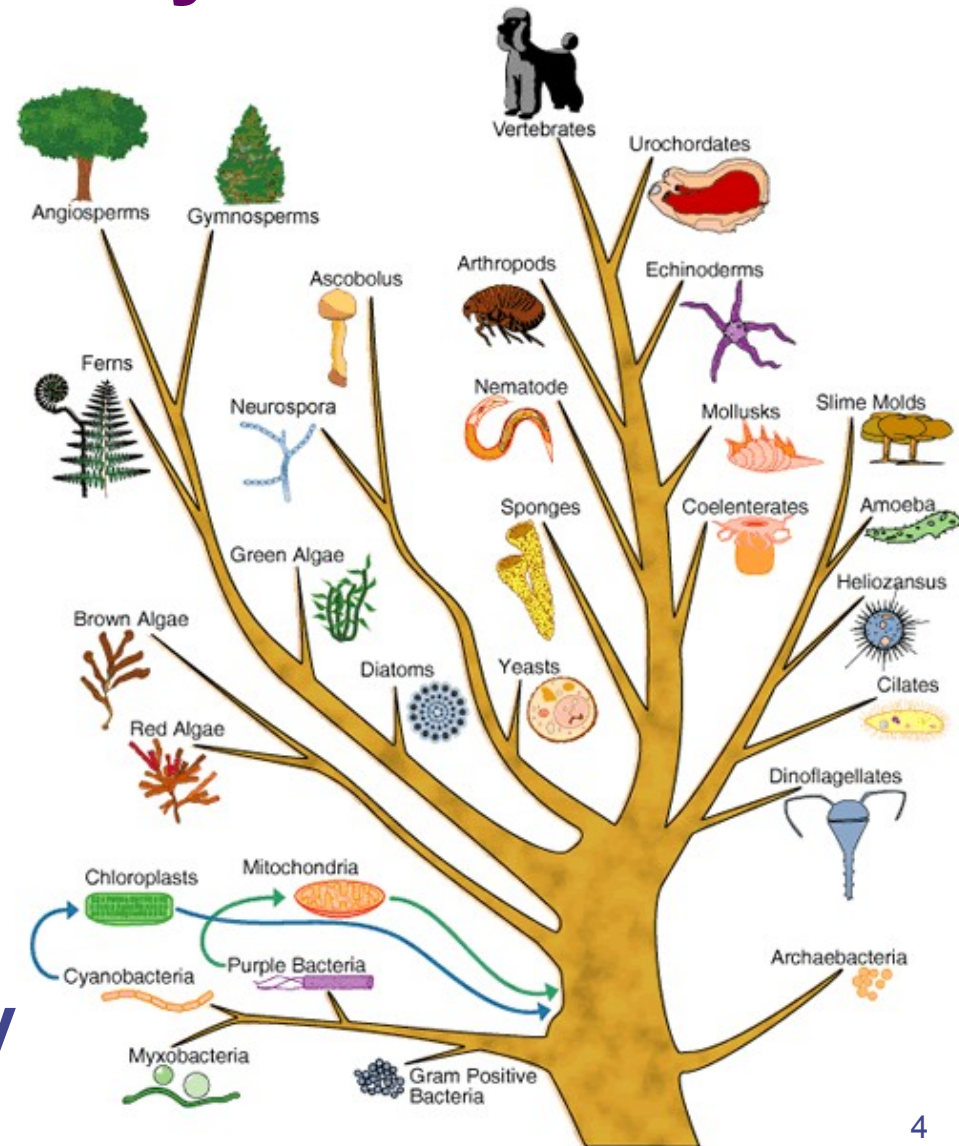
Western Meadowlark

Similar body & colorations, but are distinct biological species because their songs & other behaviors are different enough to prevent interbreeding

Diversity & Taxonomy

■ The Tree of Life

- ◆ species are the smallest unit at the ends of branches
- ◆ basic unit for organizing & categorizing living things
- ◆ smallest unit by which we measure diversity



How and why do new species originate?

■ Reproductive isolation

- ◆ biological barriers that impede members from producing viable offspring

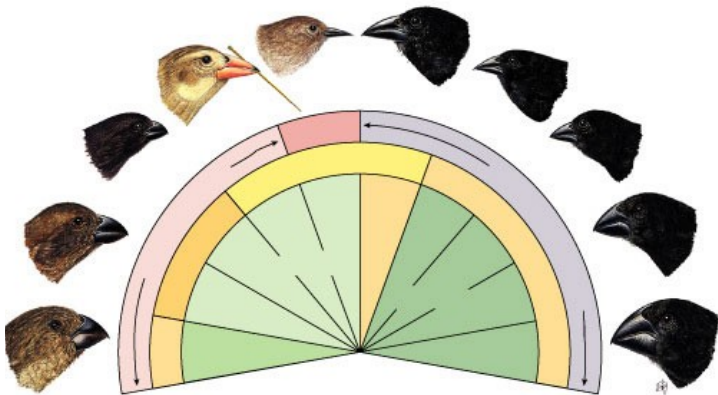
- ◆ before vs. after fertilization

- pre-zygotic barriers

- ◆ before the zygote

- post-zygotic barriers

- ◆ after the zygote



Pre-zygotic barriers

- Impede mating or hinder fertilization if mating occurs
 - ◆ habitat isolation
 - ◆ temporal isolation
 - ◆ behavioral isolation
 - ◆ mechanical isolation
 - ◆ gametic isolation



male Frigate bird
displaying to attract females₆

Ecological isolation

- Two species may occupy different habitats within same area so may encounter each other rarely

2 species of garter snake, *Thamnophis*, occur in same area, but one lives in water & other is terrestrial



lions & tigers could hybridize, but they live in different habitats:

- lions in grasslands
- tigers in forest



Temporal isolation

- Species that breed during different times of day, different seasons, or different years cannot mix gametes

Eastern spotted skunk (L) & western spotted skunk (R) overlap in range but eastern mates in late winter & western mates in late summer



Behavioral isolation

- Courtship rituals that attract mates & other unique behaviors to a species are effective reproductive barriers



Blue footed boobies mate only after a courtship display unique to their species



**Gray-Crowned Cranes
engaged in courtship display,
Kenya**



What can you say?

Mechanical isolation

- Morphological differences can prevent successful mating

Even in closely related species of plants, the flowers often have distinct appearances that attract different pollinators. These 2 species of monkey flower differ greatly in shape & color, therefore cross-pollination does not happen.



Mechanical isolation

- For many insects, male & female sex organs of closely related species do not fit together, preventing sperm transfer
 - ◆ lack of “fit” between sexual organs: hard to imagine for us, but a big issue for insects with different shaped genitals!



Damselfly penises

Gametic isolation

- Sperm of 1 species may not be able to fertilize eggs of another species
 - ◆ variety of mechanisms
 - chemical incompatibility
 - ◆ sperm cannot survive in female reproductive tract
 - biochemical barrier so sperm cannot penetrate egg
 - ◆ receptor recognition: lock & key between egg & sperm

Sea urchins release sperm & eggs into surrounding waters where they fuse & form zygotes. Gametes of different species—red & purple—are unable to fuse.

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

Postzygotic barriers

- prevent hybrid zygote from developing into a viable, fertile adult
 - ◆ reduced hybrid viability
 - ◆ reduced hybrid fertility
 - ◆ hybrid breakdown



zebroid



Reduced hybrid viability

- Genes of different parent species may interact & impair the hybrid's development

Species of salamander genus, *Ensatina*, may interbreed, but most hybrids do not complete development & those that do are frail.



Reduced hybrid fertility

- Even if hybrids are vigorous they may be sterile
 - ◆ chromosomes of parents may differ in number or structure & meiosis in hybrids may fail to produce normal gametes



Horses have 64 chromosomes (32 pairs)

Mules are vigorous, but sterile



Mules have 63



Donkeys have 62 chromosomes (31 pairs)

Hybrid breakdown

- Hybrids may be fertile & viable in first generation, but when they mate offspring are feeble or sterile



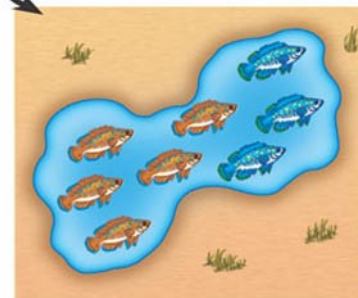
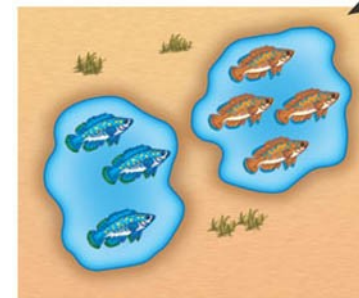
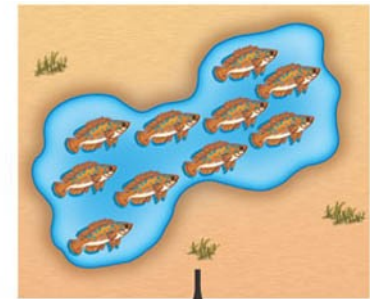
In strains of cultivated rice, hybrids are vigorous but plants in next generation are small & sterile.

On path to separate species.



Speciation

- Species are created by a series of evolutionary processes
 - ◆ populations become **isolated**
 - reproductively isolated
 - geographically isolated
 - ◆ isolated populations **evolve independently**
- Isolation
 - ◆ allopatric
 - physical separation
 - ◆ sympatric
 - still live in same area



(a) Allopatric speciation. A pop-

(b) Sympatric speciation. A

Allopatric speciation

- Allopatric = “other country”
 - ◆ geographic separation
 - migration
 - physical barrier



Harris's antelope squirrel inhabits the canyon's south rim (L). Just a few miles away on the north rim (R) lives the closely related white-tailed antelope squirrel

Sympatric speciation

- **Sympatric = “same country”**
 - ◆ some type of isolation even though populations live in same area
 - ◆ what causes this isolation?
 - **behavioral differences**
 - ◆ non-random mating
 - **physiological differences**
 - ◆ chromosomal changes
 - ◆ polyploidy
 - mostly in plants: oats, cotton, potatoes, tobacco, wheat

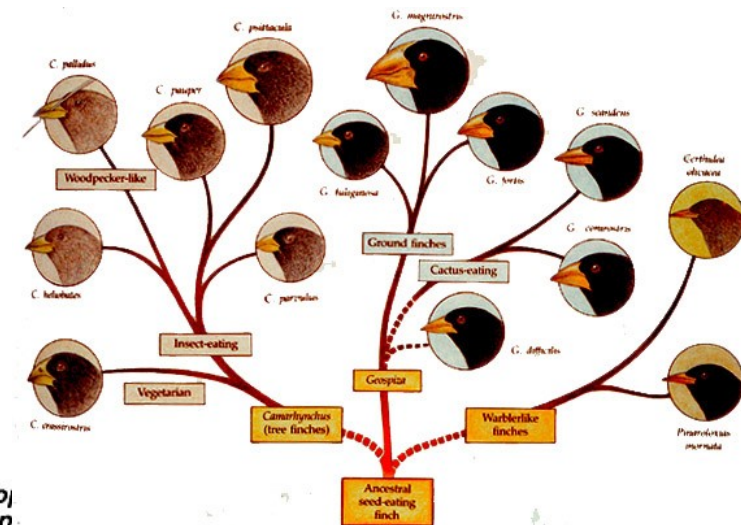
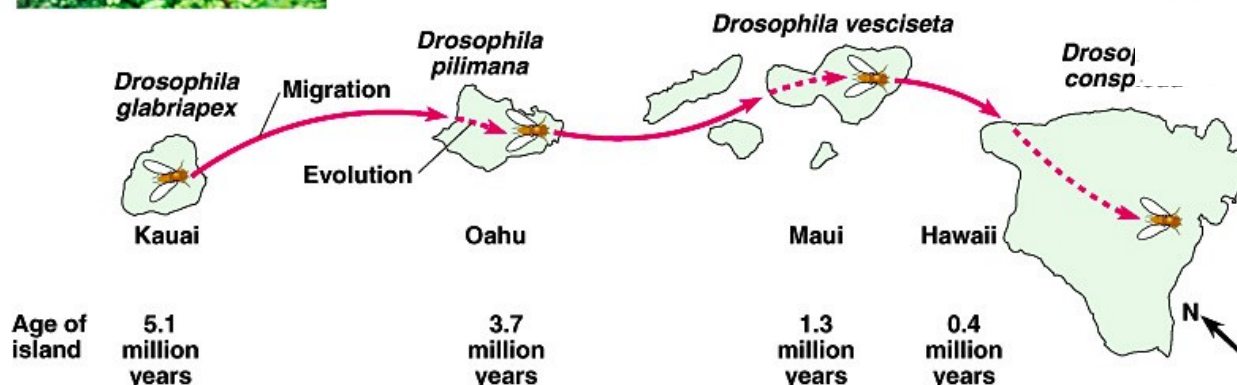


Adaptive radiation

- Evolution of many diversely adapted species when introduced to various new environmental challenges & opportunities

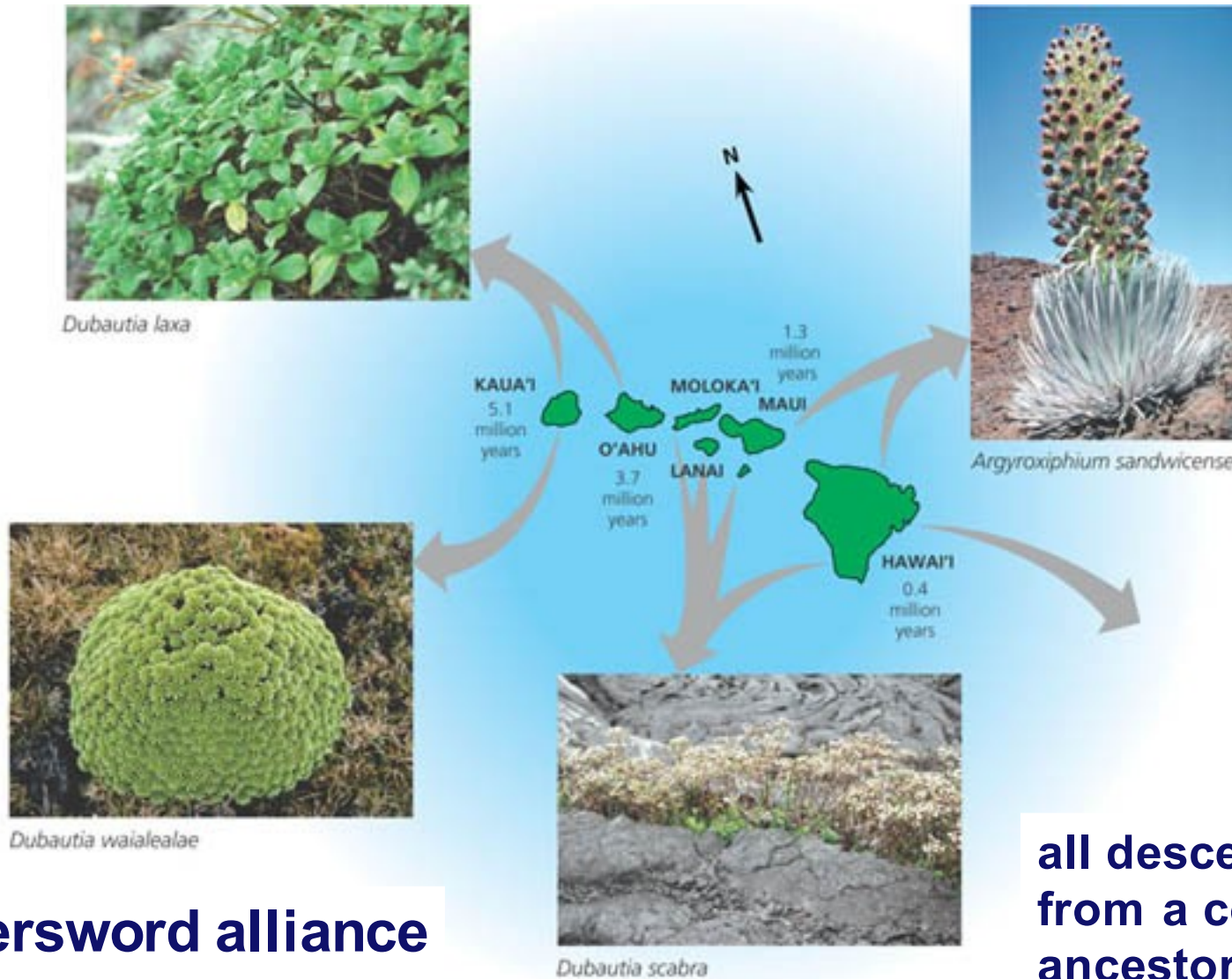


Drosophila



Geospiza

Adaptive radiation in plants

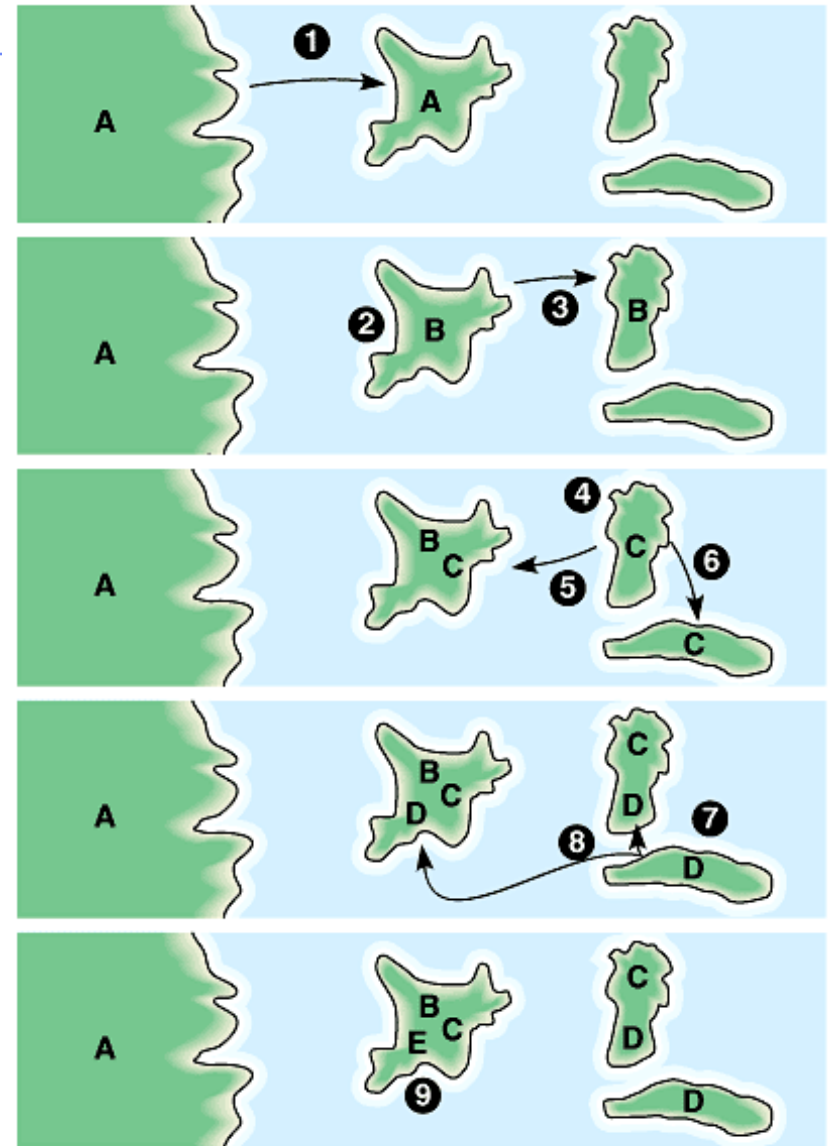


Silversword alliance

**all descended
from a common
ancestor 5mya**

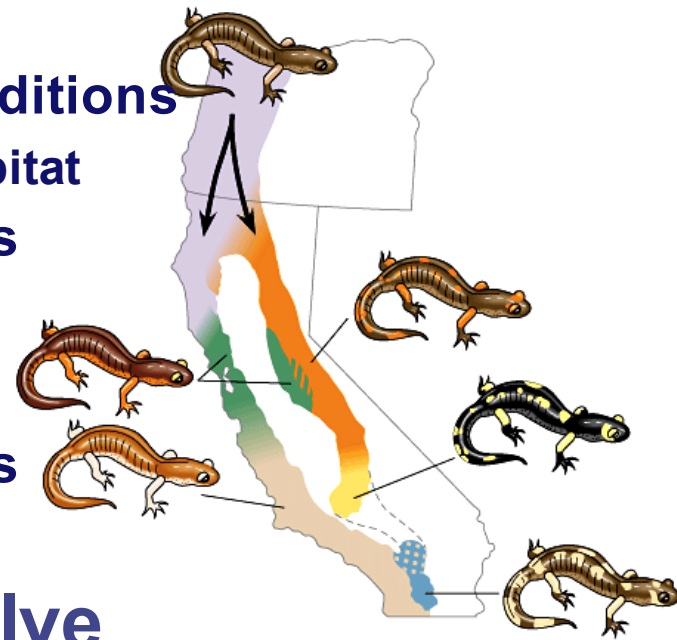
Adaptive radiation

- Many ecological niches open
- Evolution of many diversely-adapted species from a common ancestor to fill niches
 - ◆ Darwin's finches
 - ◆ mammals



Review

- **Speciation is a process**
 - ◆ **populations become isolated**
 - **geographic isolation**
 - ◆ different environmental conditions
 - food, predators, disease, habitat
 - ◆ different selection pressures
 - ◆ genetic drift
 - **reproductive isolation**
 - ◆ different selection pressures
 - sexual selection
 - ◆ **isolated populations evolve independently**



Current debate

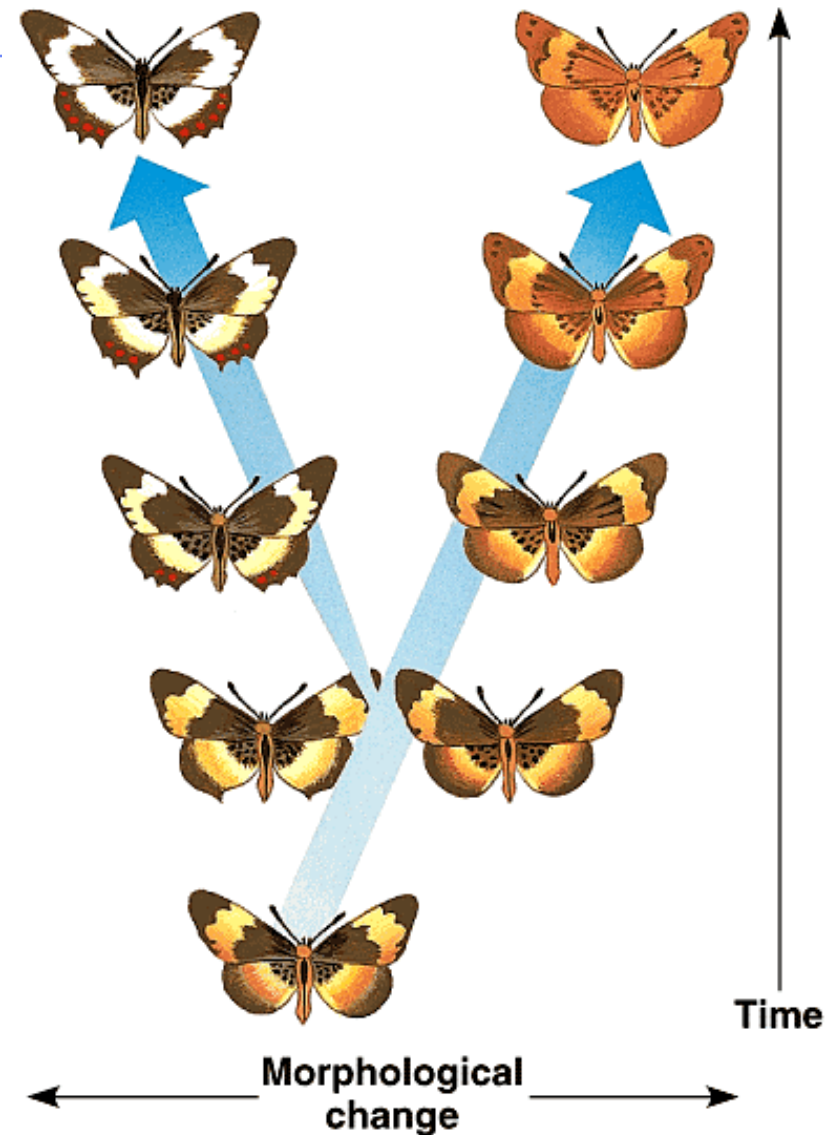
- Does speciation happen gradually or rapidly perhaps in response to environmental change
 - ◆ Gradualism
 - Charles Darwin
 - Charles Lyell
 - ◆ Punctuated equilibrium
 - Stephen Jay Gould
 - Niles Eldredge



Niles Eldredge
Curator

Gradualism

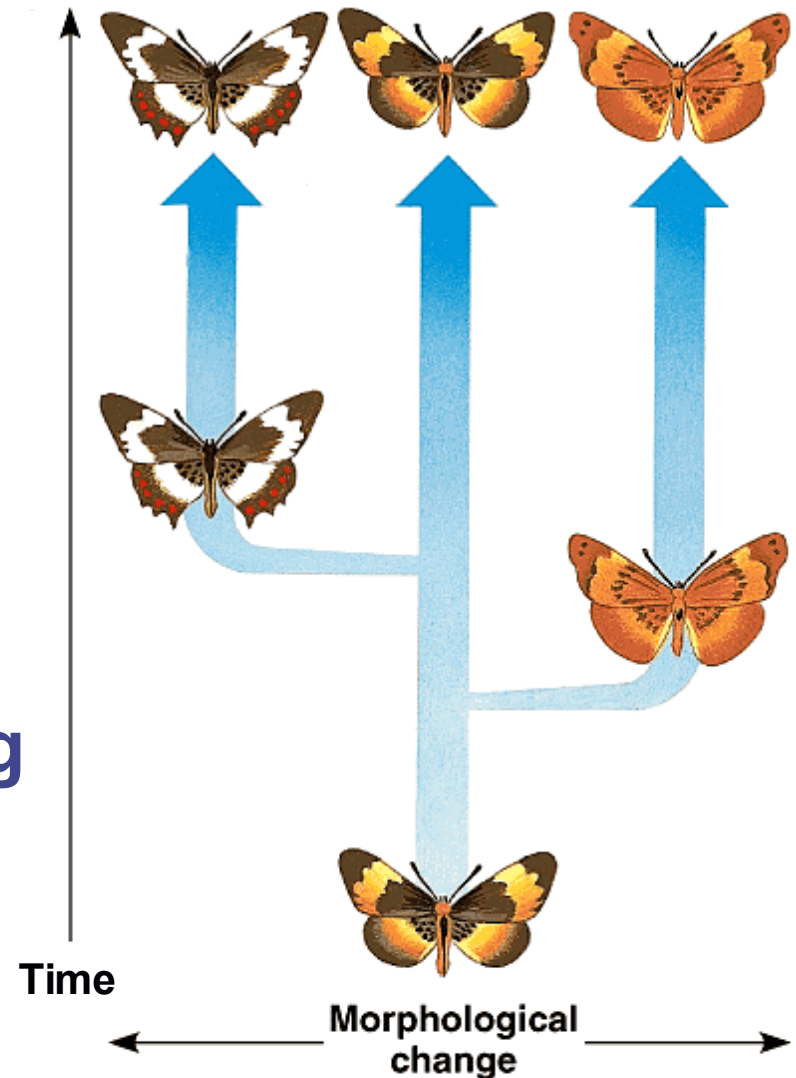
- Gradual divergence over long spans of time
 - ◆ assume that big changes occur as the accumulation of many small ones



(a) Gradualism model

Punctuated Equilibrium

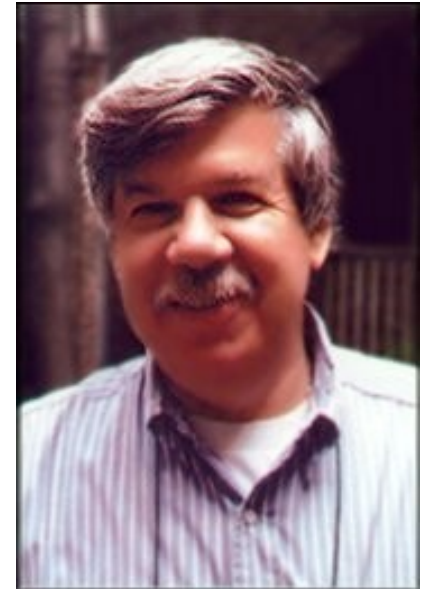
- Rate of speciation is not constant
 - ◆ species undergo most change when they 1st bud from parent population
 - ◆ as separate species, remain static for long periods of time

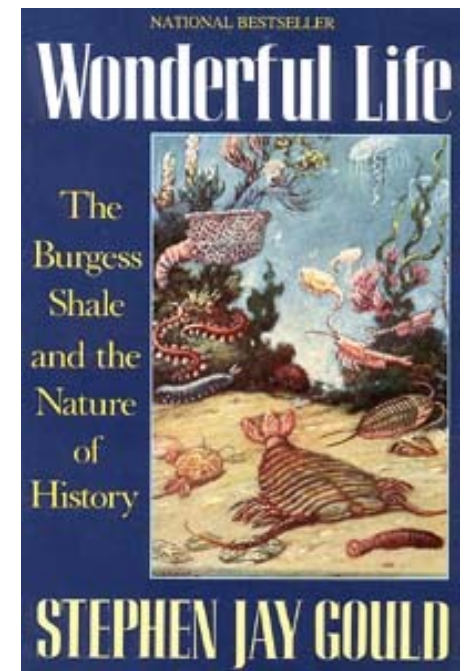
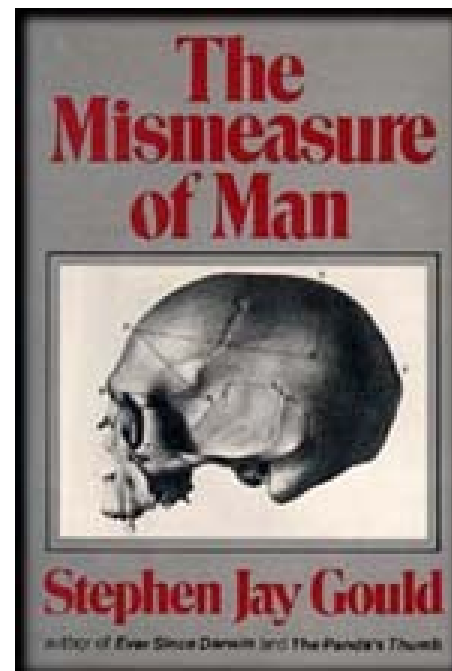
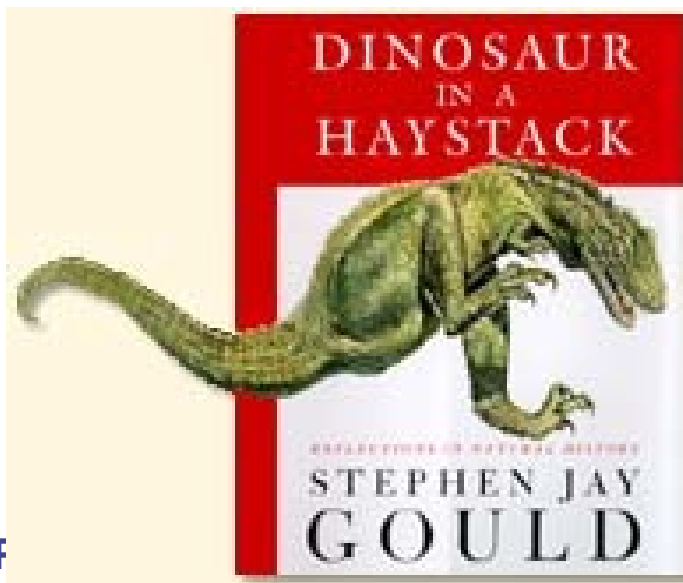
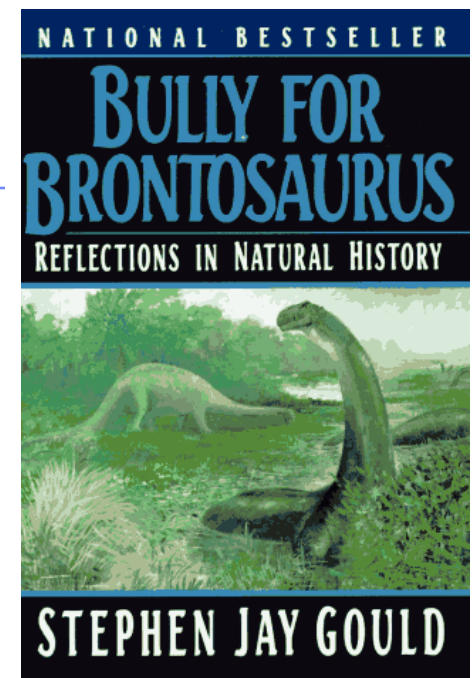
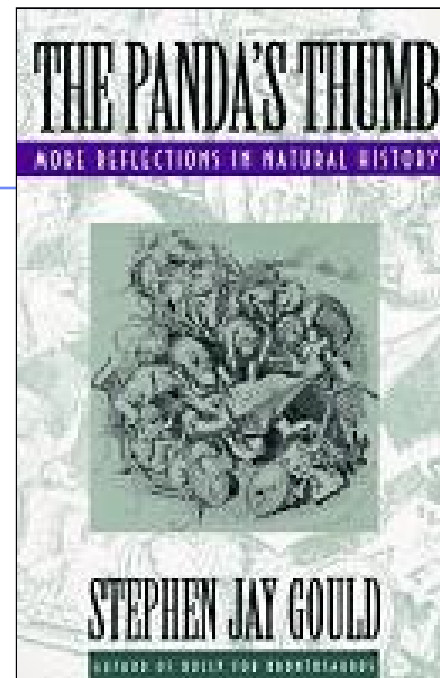
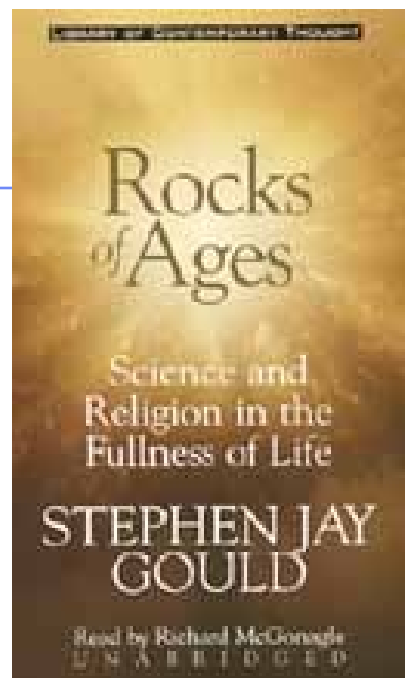
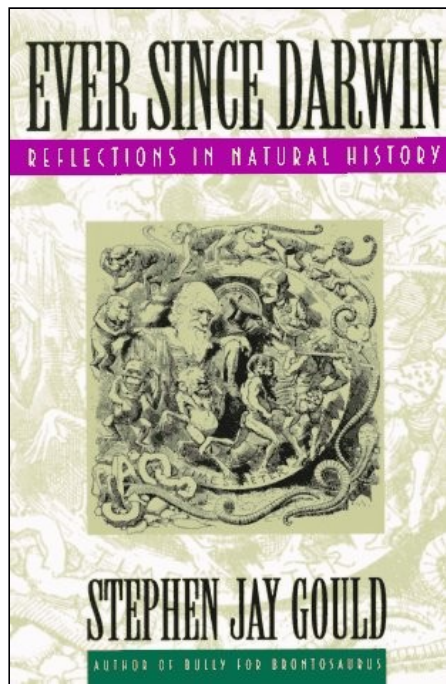


(b) Punctuated equilibrium model

Stephen Jay Gould (1941-2002)

- Harvard paleontologist & evolutionary biologist
 - ◆ punctuated equilibrium
 - ◆ prolific author
 - popularized evolutionary thought



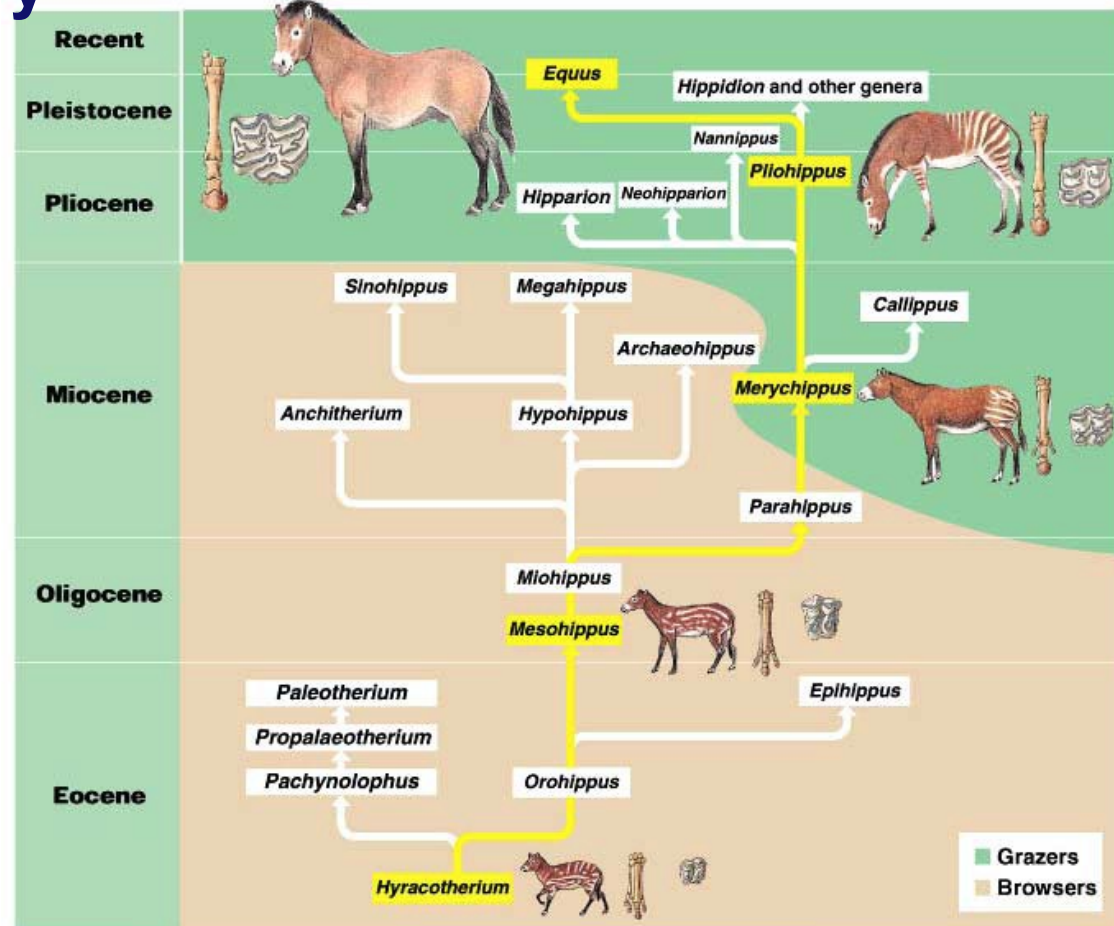


Evolution is not goal-oriented

An evolutionary trend does not mean that evolution is goal oriented. The modern horse is the only surviving twig of an evolutionary tree with many divergent trends.

It does not represent the peak of perfection. There is compromise & random chance involved as well

Remember that for humans as well!



Some interesting evolutionary trends....



Convergent evolution















- **Flight evolved 3 separate times**
 - ◆ evolving similar solutions to similar “problems”





Parallel Evolution

- Fill similar niches; have similar adaptations, but are not closely related

Niche	Placental Mammals	Australian Marsupials
Burrower	 Mole	 Marsupial mole
Anteater	 Anteater	 Numbat
Nocturnal insectivore	 Mouse	 Marsupial mouse
Climber	 Lemur	 Spotted cuscus
Glider	 Flying squirrel	 Sugar glider
Stalking predator	 Ocelot	 Tasmanian cat
Chasing predator	 Wolf	 Tasmanian "wolf"

Mimicry

- convergent evolution based on similar (protective) appearance



**Monarch male
poisonous**

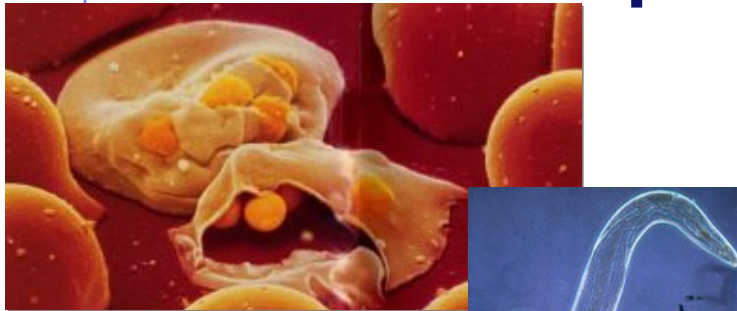
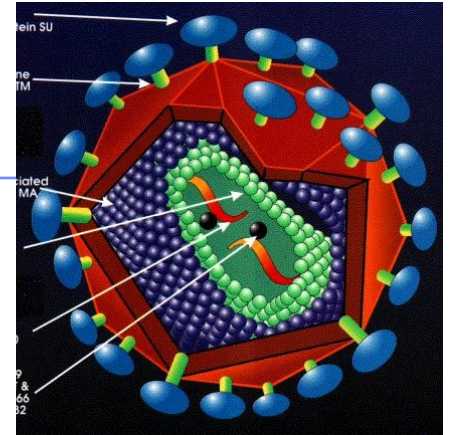


**Viceroy male
edible**



Coevolution

- Predator-prey relationships
- Parasite-host relationships
- Flowers & pollinators



Darwin Awards

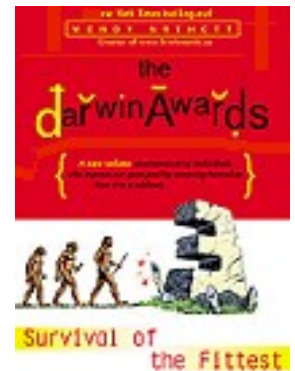


Named in honor of Charles Darwin, the father of evolution, the Darwin Awards commemorate those who improve our gene pool by removing themselves from it.

The Darwin Awards salute the improvement of the human genome by honoring those who accidentally kill themselves in really stupid ways.

Of necessity, this honor is bestowed posthumously.

www.DarwinAwards.com





Any Questions??